

Decline of the Atlantic sturgeon *Acipenser sturio* L., 1758 in Poland: An outline of problems and prospects

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ABSTRACT

Historical data on the occurrence and exploitation of Atlantic sturgeon and the causes behind its decline were reviewed, using publications from the 18th to the 20th centuries. The Atlantic sturgeon *Acipenser sturio* L., 1758 in Poland was originally found in the Vistula and Oder Rivers and their tributaries, to the upper parts of their watercourses. Over the following centuries, its range has been greatly reduced, and by the mid-1960s it had completely disappeared from Polish waters. The last sturgeon were caught in the lower Vistula River in 1965. Today, the species is considered extirpated. From the Middle Ages, the Atlantic sturgeon was intensively caught in rivers and lagoons, mainly by floating nets. The period of maximum fishery exploitation in the lower Vistula River and Gulf of Gdansk was about 1500, and the first symptoms of sturgeon overexploitation occurred around 1600. The main reasons for stock decline in Polish rivers are, chronologically: (1) long-term overexploitation; (2) water extraction; (3) hydraulic engineering (including stream regulations, damming and construction of harbours; and (4) industrial and agricultural pollution. At the end of the 19th century, the accumulated and prolonged influence of these factors reached a critical level. Legal regulations for sturgeon protection, introduced from the 19th century, did not stop its decline. In the last decade, a new programme for the Atlantic sturgeon's restoration in Polish rivers has been proposed, based on the experience in production of other acipenserid species under controlled conditions. The main idea of the programme is to establish some parts of former spawning populations in the Oder and Vistula River systems by introducing fish reared artificially. This proposition has not been implemented due to the lack of spawners required to produce stocking material, a requisite for the establishment of reproductive populations.

Key words: Distribution, exploitation, conservation, North Sea.

RESUMEN

Declive del esturión atlántico *Acipenser sturio* L., 1758 en Polonia: un esbozo de problemas y perspectivas

Se revisaron los datos históricos de presencia y explotación del esturión atlántico *Acipenser sturio* L., 1758 y las causas de su declive, utilizando publicaciones de los siglos XVIII a XX. El esturión atlántico en Polonia se encontraba originalmente en los ríos Vístula y Oder y sus afluentes hasta las partes superiores de sus cursos de agua. En los últimos siglos su distribución se ha reducido de forma importante, y a mediados de la década de los sesenta desapareció completamente de las aguas polacas. El último esturión se capturó en el tramo inferior del río Vístula en 1965 y hoy la especie se considera extirpada. Desde la Edad Media el esturión atlántico fue capturado intensamente en ríos y lagunas, principalmente con redes flotantes. El periodo de máxima explotación pesquera en el río Vístula inferior y en el golfo de Danzig tuvo lugar hacia 1500, y los primeros síntomas de sobreexplotación del esturión se manifestaron alrededor de 1600. Las principales razones para el declive del stock en los ríos polacos son, cronológicamente: (1) la sobreexplotación a largo pla-

zo; (2) la extracción de agua; (3) la ingeniería hidráulica (incluidas las regulaciones fluviales, la construcción de presas y la de puertos), y (4) la contaminación industrial y agrícola. A finales del siglo XIX, la influencia acumulada y prolongada de estos factores alcanzó un nivel crítico. Las regulaciones legales para la protección del esturión, introducidas desde el siglo XIX, no detuvieron este declive. En la última década se ha propuesto un nuevo programa para la recuperación del esturión atlántico en los ríos polacos, basado en la experiencia en la producción de otras especies de acipenséridos en condiciones controladas. El planteamiento principal del programa es establecer algunas partes de las anteriores poblaciones reproductoras en las cuencas de los ríos Vístula y Oder introduciendo peces criados artificialmente. Esta propuesta no se ha podido llevar a cabo debido a la falta de los reproductores necesarios para producir el material a repoblar, un requisito para el establecimiento de las poblaciones reproductivas.

Palabras clave: Distribución, explotación, conservación, Mar del Norte.

INTRODUCTION

The Atlantic sturgeon *Acipenser sturio* L., 1758 inhabited the coastal waters of Europe from the Peczora River to the Rioni River in the Black Sea. Being an anadromous fish, with a wide range for feeding migrations, the species has always been subjected to intensive catches. Historic sources reveal mass and wasteful exploitation of this species throughout Europe (Mohr, 1952). Continuously decreasing abundance of all European sturgeon populations were noted at the turn of the 19th and 20th centuries. The present paper describes the course of and identifies the main reasons for the disappearance of the sturgeon in Polish waters.

CHANGES IN STURGEON OCCURRENCE IN POLAND

Until to the end of the 19th century (figure 1)

Publications from this period recorded the occurrence of sturgeon from these waters, which might be considered as its maximal area of natural distribution. The sturgeon was a common fish in the Polish Baltic Sea until the second half of the late 19th century (Rzaczynski, 1721, 1736; Kluk, 1780; Bloch, 1784; Rathke, 1824; Zawadzki, 1840; Klinsmann, 1848; Heckel and Kner, 1858; Siebold, 1863; Holland, 1871; Benecke, 1881; Möbius and Heincke, 1883; Nowicki, 1889; Walecki, 1889). The species occurred massively in the Vistula River (Rzaczynski, 1721, 1736; Kluk, 1780; Walecki, 1863; Jachno, 1867; Taczanowski, 1877; Nowicki, 1879, 1880, 1889; Sobieszczanski, 1894; Fiszer, 1896; Anon., 1898b), the Oder River (Bloch, 1784; Gloger, 1833; Heinrich, 1856; Holland, 1871;

Borne, 1882; Anon., 1898a), and in some rivers (e.g. the Pasleka) entering the Vistula lagoon (Anon., 1899). The Oder and Vistula Rivers, together with their tributaries, were major spawning grounds of the Baltic sturgeon populations. Their estuaries were major feeding grounds. According to Polish literature, the sturgeon was found throughout the Vistula River. The species has also been recorded in its tributaries: the San River (Ladowski, 1804; Heckel and Kner, 1858; Walecki, 1863, 1864; Nowicki, 1879, 1889; Wilkosz, 1896), the Dunajec and Wisloka Rivers (Nowicki, 1879, 1880), the Wislok River (Nowicki, 1880), the Bug, Narew and Drweca Rivers (Walecki, 1864; Anon., 1883) and the Bzura River (Walecki, 1863). Grabda (1968) supposed that the main spawning grounds of sturgeon were located in the San River, and right-bank tributaries of the upper Vistula River. In the Oder River, sturgeon occurred as far as Raciborz. The spawning grounds were probably located in the regions of Olawa and Brzeg (Przybyl, 1976). From the Oder River, sturgeon entered the Warta River (Rzaczynski, 1721; Walecki, 1864; Borne, 1882; Anon., 1898a) up to near Kolo. The main spawning grounds of this population were found in the middle Warta River, south of Poznan, and in the Gwda and Drawa Rivers (Schulz 1911).

The period 1900-1945 (figure 2)

Publications from this period presented some information on declining abundance in particular regions, changes in occurrence, and discussion of possible reasons. Information about occurrence of sturgeon in the Baltic Sea and its gulfs is cited in Seligo (1902), Demel (1924, 1925, 1927, 1933), Jakubski (1924), and Kulmatycki (1932a). Yet at

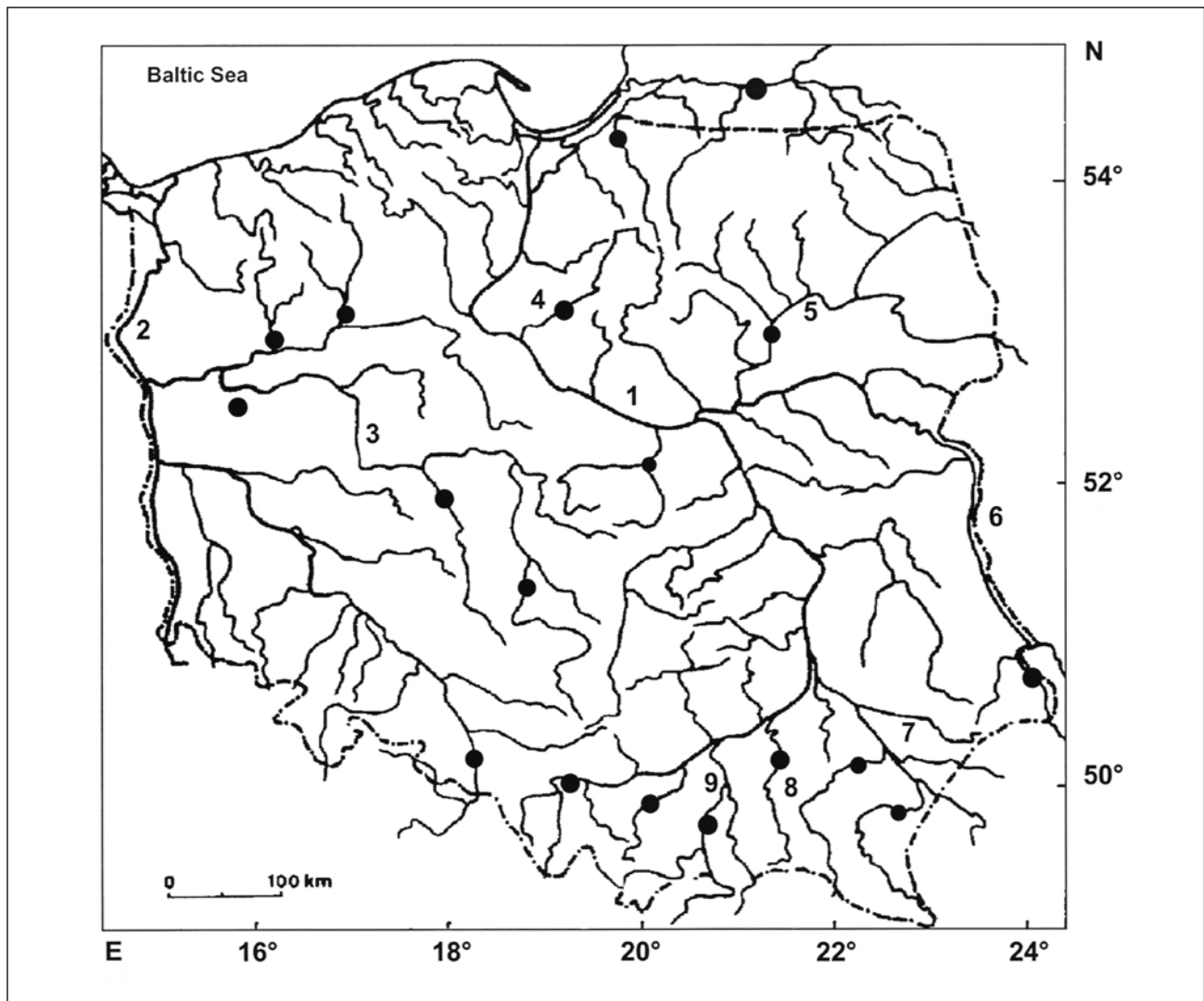


Figure 1. Occurrence of *A. sturio* in Poland before 1900. Black dots show the uppermost known locations in particular rivers recorded by different sources in the literature. Rivers: (1): Vistula; (2): Oder; (3): Warta; (4): Drweca; (5): Narew; (6): Bug; (7): San; (8): Wisłoka; (9): Dunajec

the beginning of the 20th century, sturgeon was caught in the Vistula River in “considerable quantities” (Seligo, 1902, 1906, 1919, 1920; Wilkosz, 1904; Berg, 1911); however, later it declined rapidly (Kowalski *et al.*, 1910; Sasorski, 1922; Anon., 1923; W. J. S., 1929; Kulmatycki, 1926; Sakowicz, 1931; Blazejewski, 1934). The species presence was still confirmed in Vistula River tributaries, such as the Drweca (Seligo, 1902), Dunajec (Anon., 1925), and San Rivers (Kowalski *et al.*, 1910). After World War I, the main sturgeon spawning site was in the Drweca River (Grabda, 1968). In the Oder River, sturgeon occurrence was already considerably rarer (Anon., 1900, 1919, 1936; Szmyt, 1904; Pax, 1916, 1921, 1925a, 1925b; Wunder, 1933). A

similar situation was noted in the Warta River (Kornaszewski, 1907; Kowalski *et al.*, 1910; Schulz, 1912; Kulmatycki, 1926, 1932b, 1936; and Sakowicz 1930).

The period 1945-1965 (figure 3)

Publications from this period recorded a decreasing number of specimens in catches. Sturgeon occurrence was sporadically recorded in the Pomeranian Gulf (Kraczkiewicz, 1967; Grabda, 1968; Grabda and Waluga, 1968), in the Szczecin lagoon (Kozikowska, 1957; Gasowska, 1962), and in the Gulf of Gdansk (Staff, 1950; Gasowska, 1962; Rudnicki, 1963, 1966; Grabda, 1968; Turoboyski,

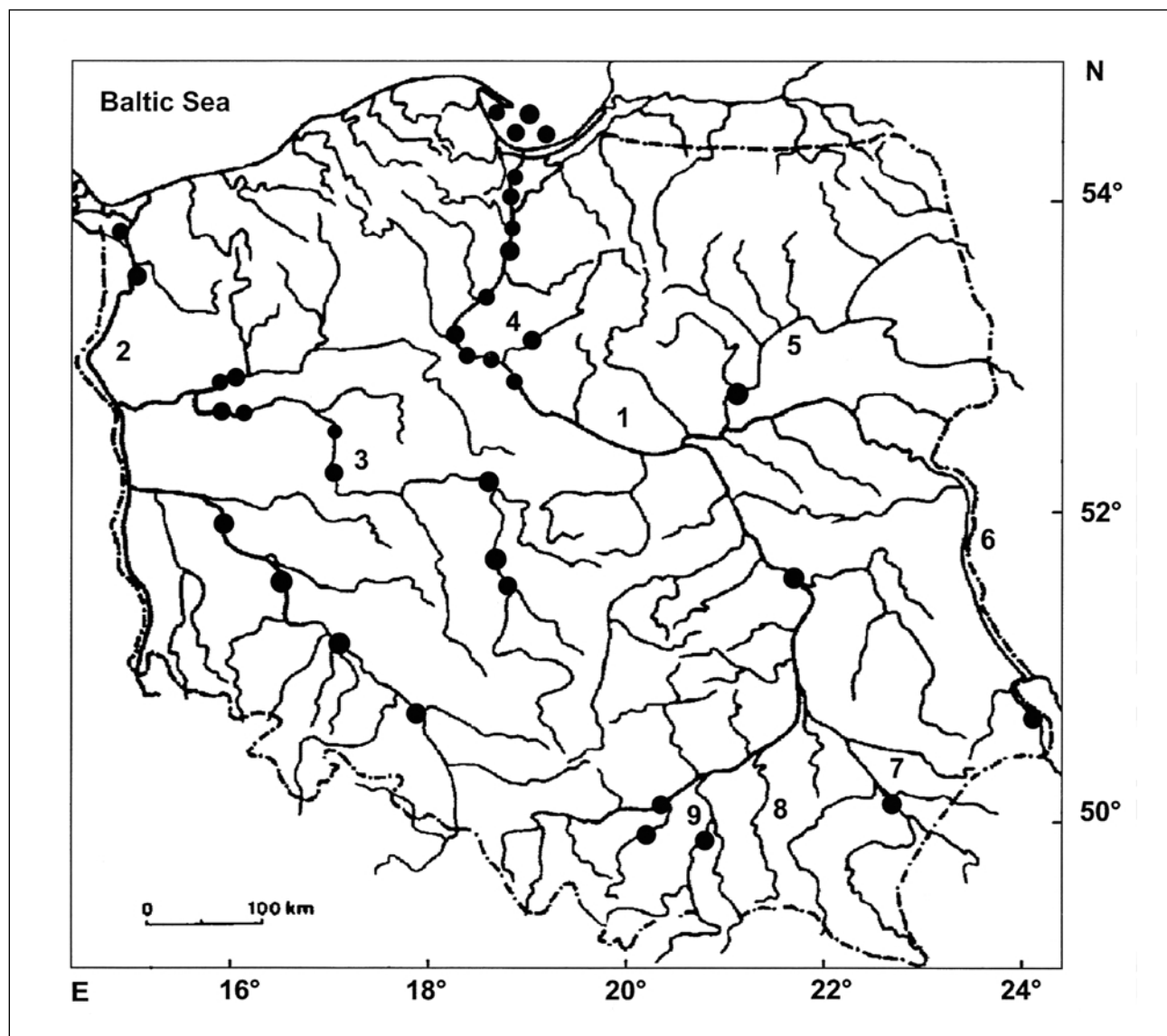


Figure 2. Occurrence of *A. sturio* in Poland between 1900 and 1945. Black dots show where groups or single sturgeon were caught, as recorded by different sources in the literature

1968). Isolated specimens were still caught in the lower and middle Vistula River (Chrzanowski, 1947; Poczopko, 1955; Kujawa, 1962; Rudnicki, 1963, 1966; Zelechowska, 1964; Kajzer, 1966; Grabda, 1968) and in the lower and middle Oder River (Kardaszewski, 1947; Kaj, 1948). They were also recorded in Oder River tributaries, such as the Gwda and Reda Rivers (Kardaszewski, 1947) and the Warta River (Kaj, 1948; Jaskowski, 1962; Rudnicki 1966), as well as Vistula River tributaries, such as the Drweca (Grabda, 1968), Narew (Staff, 1950; Rolik, 1959; Rudnicki, 1963, 1966; Anon., 1965) and San Rivers (Staff, 1950; Anon., 1956; Rolik, 1959; Rudnicki, 1963).

MAIN CAUSES OF STURGEON POPULATION DECLINE

Intensive exploitation

From the earliest times the Vistula lagoon and Gulf of Gdansk were an area of intensive sturgeon exploitation. During the 10th-12th centuries, sturgeon was one of the main fishes caught in Gdansk (Lega, 1949). Excavations of a former fishery settlements there, dating from the 10th-14th centuries, found gigantic quantities of sturgeon bony plates, in a good state of preservation (Urbanowicz, 1965). About 80 % of the fish remains, from layers

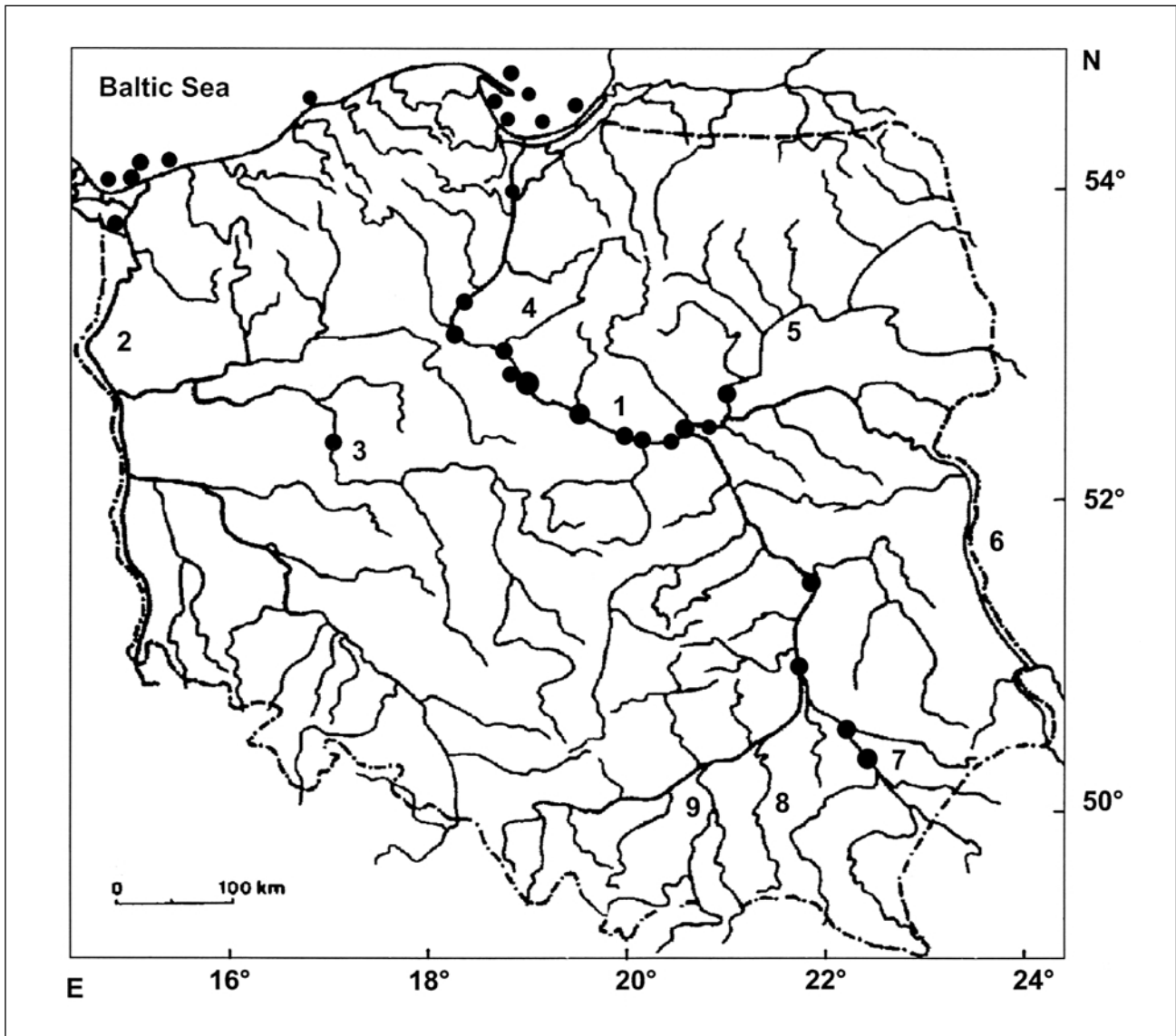


Figure 3. Occurrence of *A. sturio* in Poland between 1945 and 1965. Black dots show where single sturgeon specimens were caught, as recorded by different sources in the literature

of the 13th and 14th centuries, originated from sturgeon, mostly from specimens with a length of about 200-300 cm (Jazdzewski, 1954). The most important route in sturgeon migration between the lower Vistula River and Vistula lagoon must be considered the Nogat River. In 1395, after filling the Nogat River channel with sand from the Vistula River, the disappearance of sturgeon in catches from the lower course of the Vistula was noted (Olszewski, 1948). For many centuries, sturgeon was an object of intensive exploitation, reaching its maximum in the 16th-17th centuries. At that time, sturgeon catches and trade were monopolised by the city of Gdansk, and caviar was exported to

England, France, and Lithuania (Ropelewski, 1963). Pilawa was the main centre of fishing and trade for the Vistula lagoon. In the early 18th century an increased quantity of small sturgeons was noted in the catches, a first sign of overexploitation. With the end of the 18th century, catches of sturgeon in Vistula lagoon and the Gulf of Gdansk lost all importance (Ropelewski, 1963). In the 19th century, the main sturgeon fishery became the outlet of the Vistula River.

In the Warta River (Oder River drainage) a period of increased sturgeon catches was reported in 1892-1894 (Grotrian, 1896). Fishes were most often caught in the region between Oborniki and Srem

(Kornaszewski, 1907). Grotian (1896 after Przybyl, 1976) hypothesises that wasteful catching of spawned sturgeon from the Warta River caused the onset of the fishery's decline in that area.

In the mid Vistula River, the most intensive sturgeon fishery was between the cities of Pulawy and Zawichost, and between Nieszawa and Ciechocinek. In the 1850s and 1860s, sturgeon was the leading fish on the Warsaw market. At that time, Vistula sturgeon were the main source of caviar sold in St. Petersburg (Walecki, 1864). At the end of the 19th century, a stable sturgeon fishery still existed in the Gulf of Gdansk and Vistula lagoon. Fishes were caught using special nets, called *Störlanken* (Anon., 1886). The weight of individuals caught ranged from 25 to 35 kg, and length from 170 to 190 cm (Anon., 1887). The Vistula River sturgeon fishery rapidly declined at the turn of the 19th century. According to Grabda (1968), intensi-

fication of this decline was recorded in 1905-1908. The situation is well illustrated by catch data from the outlet of the Vistula River and Gulf of Gdansk, according to Zelechowska (1964) (figure 4). In later years, sporadic sturgeon catches were recorded in the lower Vistula River. Most often, there were individuals about 20-30 cm in average length. To catch sturgeons in this region, trap nets (sturgeon traps) have been used, whereas above the city of Torun, sturgeon were caught in floating nets, called *dryga*. According to official data, in 1919-1930 in the lower Vistula River, 39 sturgeon were caught, with a total weight of 3774 kg (Grabda, 1968). According to Rudnicki (1963), in the middle Vistula River, in 1934-1935, about 1 t of sturgeon per year was caught, of which 45 % were caught illegally out of season. After World War II, catch records have been exceptionally rare. Grabda (1968) described 10 such records in the lower

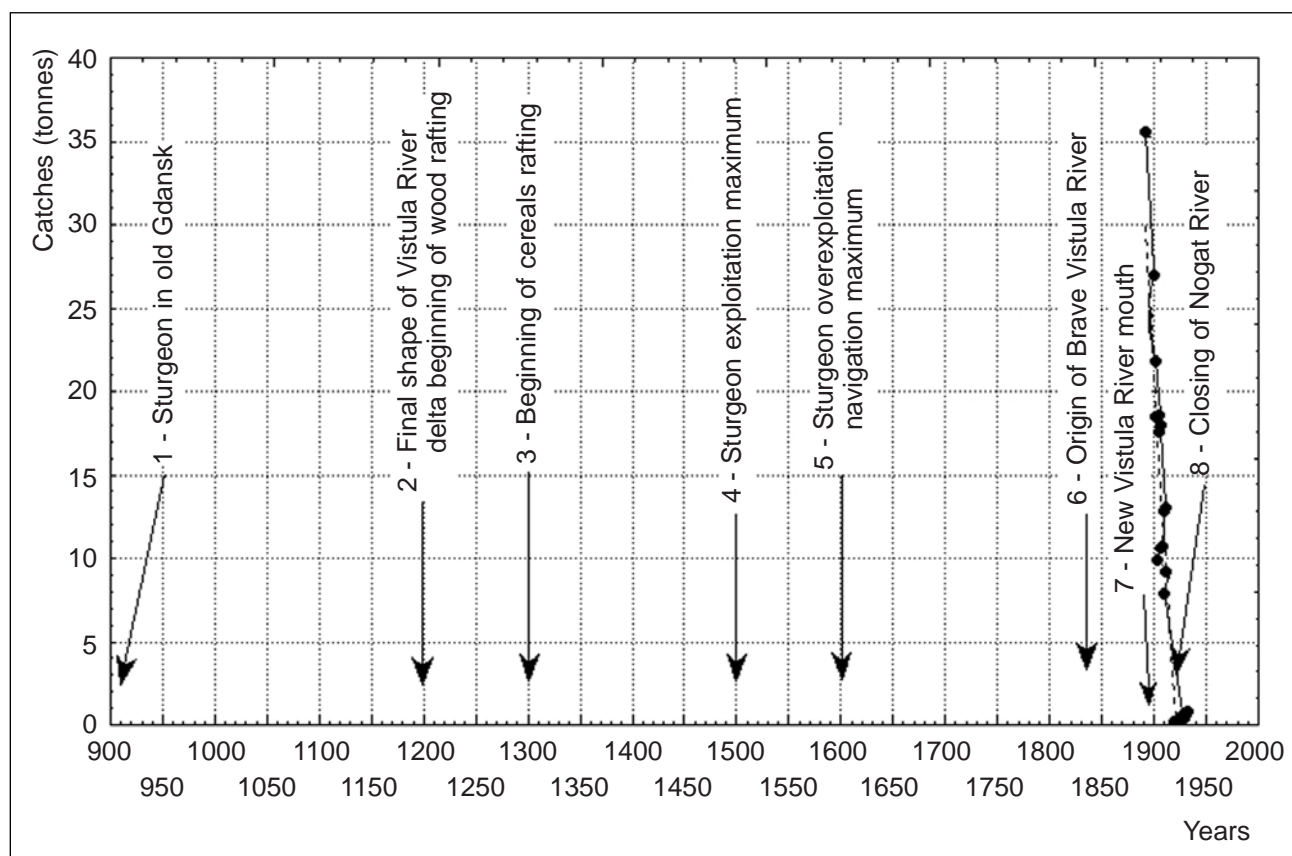


Figure 4. Timeline for *Acipenser sturio* occurrence in the Vistula River. The latest data about sturgeon catches taken from Kulmatycki (1932b) and Zelechowska (1964). Explanations of breaking points: (1): sturgeon comprised 54 % of catches in old Gdansk (Urbanowicz, 1965); (2): final shape of the Vistula River delta (Mikolajski and Wodziczko, 1929), sturgeons comprised 12 % of catches in old Gdansk (Urbanowicz, 1965), beginning of wood rafting (Rybczynski, 1935); (3): beginning of cereals rafting (Rybczynski, 1935); (4): maximum sturgeon exploitation (Ropelewski, 1963); (5): sturgeon overexploitation (Ropelewski, 1963), navigation maximum (Rybczynski, 1935); (6): origin of Brave Vistula River (Rybczynski, 1935); (7): new Vistula River mouth in 1895 (Rybczynski, 1935); (8): closing of the Nogat River (Rybczynski, 1934)

Vistula River. In the Polish zone of the Baltic Sea, approximately 10-15 sturgeons were caught in the postwar period (Grabda, 1968). After 1945 sturgeons were caught or observed 25-30 times (Dyduch, 1979). According to Kolman (1996), after introduction of full specific protection of sturgeon, during 1936-1965, 27 records of catches were officially confirmed in the Vistula River and its tributaries. Their recorded body lengths were over 150 cm, and weight ranged from 95-211 kg. In 1952-1955, 7 sturgeon were observed in the lower Vistula, and 2 in the San and Narew Rivers. Since the second half of the 1960s, no sturgeon catches have been recorded in Polish waters. Certain confusion regarding identification of later sturgeon specimens and where they were sighted was caused by the appearance of other acipenserids in Polish waters, originating from introduction or aquaculture. These specimens (mainly *Acipenser ruthenus* L., 1758; *Acipenser gueldenstaedtii* Brandt & Ratzeberg, 1833; *Acipenser baerii* Brandt, 1869, or their hybrids) have been found in the Gulf of Gdansk (Bartel, 1968) and the Vistula River (Nabialek, 1974, 1976).

Reconstruction of river beds and navigation

At the beginning of the 13th century, wood exports from Gdansk began, and in the 14th century, cereal exports. This started a period of intensive development of navigation on the Vistula River, and river-bed regulation (Rybczynski, 1934, 1935). Maximum navigation activity was in the 17th century. Hydrotechnical works related with drainage of Vistula delta began in lower the Vistula River in 1856. At present the Vistula is modified partly in its upper course and completely in the lower. Closing of the Drweca River mouth with a dam near Lubicz blocked migration of spawning sturgeons in this river.

Regulation of the Oder River began in the 18th century

Between 1888 and 1895, the river was channelled from Kozle to the Nysa Kłodzka River. In 1905-1917, regulation was extended below Wrocław and 22 sluices were built there. At present, this river is regulated along its entire length. The Warta River was also channelled from the mouth of the

Prosna River, as were the Odra and Notec Rivers (after 1869). According to Schulz (1911), steamship navigation was a major destructive influence on sturgeon spawning grounds in the Warta River. Kulmatycki quoted the opinion of fishermen from the Warta River, who said that the disappearance of sturgeon in the river was connected with its channelisation. This began in 1819. In 1896, the Warta River was dredged to the mouth of the Prosna River, which had an impact on sturgeon spawning grounds. As a result of the construction of the Bydgoski Channel (1774), the lower Notec River was transformed between 1891-1898 into a navigable channel with 11 sluices, cutting off sturgeon spawning grounds in the Gwda River (Przybył, 1976). Blocking of passage to the spawning grounds resulted in a dramatic decline in the effectiveness of natural reproduction. Specimens living individually often died during the spawning period, as a result of negative changes caused by the resorption of unresorbed sexual products (Grabda and Waluga, 1968).

Pollution

Kulmatycki (1932b) highlighted the convergence of sturgeon disappearance with the development of industry. In waters of Greater Poland and Pomerania, this took place at the turn of the 19th and 20th centuries. Greater Poland concentrated over 55 % of all production of agriculture industry of Poland (Kulmatycki, 1929). In the Oder River basin, intensive development of industry (textile workshops, metal workshops, paper-mills, smelting works of iron and glasses) began in the 17th century (Maleczynski, 1963). Rapidly increasing quantities of sewage coal and chemical wastes had significant influence on spawning and feeding grounds of young sturgeons (Starmach, 1951).

Changes in the mouth of the Vistula River (figure 5)

The Vistula River delta gained its shape about 1200 (Mikolajski and Wodziczko, 1929). To the end of the 14th century, the Nogat and Vistula Elblaska Rivers were the main outlets of the Vistula (Rybczynski, 1935). From 1550, 87 % of Vistula waters passed through the Nogat, whereas by 1600 this

had decreased to 75 %. Further decline took place around 1800, with only 60 %, and in the first half of the 19th century, only about 30 % of Vistula runoff was associated with the Nogat outlet (Mikulski, 1963). Sturgeon at that time could enter the Vistula through 15 branches. In 1840, the Vistula River broke a belt of dunes and formed a new outlet to sea (Brave Vistula). In 1895, the new mouth was constructed through the Schievenhorst dunes. The Gdansk and Elblag arms of the river were closed with sluices. In 1915, the Nogat River was closed with a sluice, as well (Rybczynski, 1934). For the sturgeon population, only one entry to the Vistula remained. Fishes feeding in Vistula lagoon lost pre-

vious connecting arms to the river. According to the opinion former fishermen, reconstruction of the Vistula River mouth in 1895 caused the disappearance of sturgeon in its lower course (Grabda, 1968).

According to Dyduch (1979), the following negative factors, in chronological order, influenced sturgeon populations in Poland: (1): long-term overexploitation (Michalski, 1967); (2): water extraction; (3): hydraulic engineering (Kulmatycki, 1932b); (4): change of hydrobiological conditions-pollution of water in rivers (Starmach 1951); and (5): changes of feeding conditions in the Baltic Sea.

At the end of the 19th century, the accumulated and prolonged influence of these factors reached a

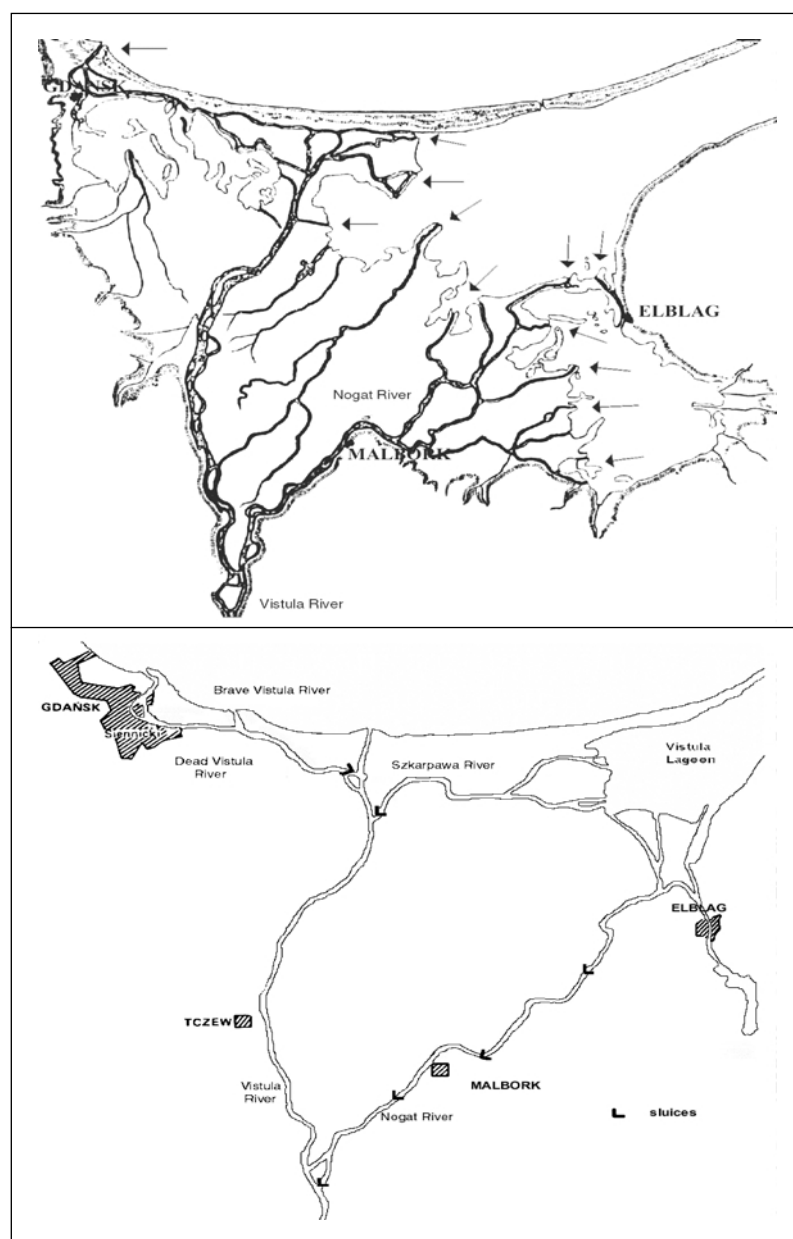


Figure 5. Changes in the Vistula River delta. Upper section-delta about 1300 (from Bertram, after Samsonowicz, 1967, modified). Lower section-delta in 1935 (after Rybczynski, 1935). Arrows indicate entries to the Vistula River for sturgeons

critical level for the last Polish sturgeon population (figure 5).

LEGAL PROTECTION AND PROJECT OF RESTORATION OF THE SPECIES

In the Middle Ages, a factor limiting common pressure on sturgeons was the *regale*, e.g. the royal monopoly on catching of fishes with large nets, and on special fish species (Lega, 1949). The rule of navigation's priority over fishery was very important. The ban on stable fishing devices (e.g. dams), blocking or partitioning the river indirectly favoured the protection of migrating sturgeons. In connection with intensive navigation development in the Oder River, Silesian princes forbade partitioning of rivers as early as 1337. This prohibition was renewed in 1349, 1355, and 1375 (Tobiasz, 1962). The Teutonic Order effected a limitation for Oliwa monastery, forbidding putting out sturgeon nets at a distance of about 840 m from the Vistula outlet (Grabda, 1971). Statutes of Piotrków from 1447 implemented the freedom of navigation and the prohibition of partitioning of the Dunajec, Wisłok, San, Wieprz, Tyosemienica, Bug, Narew and Nida Rivers (Kutrzeba, 1918). According to 19th century Prussian legislation, sturgeon was protected from 15 July to 31 August. In 1932, the Minister of Agriculture instituted the first rules of sturgeon protection in Poland. At first, there was seasonal protection from 15 July to 15 August. This ban was then moved to an earlier period (1 June to 31 July). Additionally, individuals below 100 cm length were protected throughout the year. Simultaneously, authorities of the Free City of Gdansk introduced protection of sturgeon in the lower Vistula and the Gulf of Gdansk from 1 July to 31 August. However, this was partial protection only, because fishes migrated to spawning grounds as early as April, and from March to July the catches were greatest (Kulmatycki, 1932b). The law did not protect sturgeon during migrations to and from spawning grounds. Rudnicki (1963) estimated that in 1934-1935, only half of caught fish were registered in official data. From 1 October 1936, sturgeon in Poland became fully protected. This protection was confirmed in all following laws, which are still in force (from 1 April 1995).

Only one attempt at reproduction and artificial farming of sturgeon was undertaken, by Prof. A.

Seligo in 1906-1907. He created a station for sturgeon reproduction at Tczew (Kulmatycki, 1932b). The undertaking did not have favourable results, because of problems with simultaneously acquiring males and females to reproduction.

In 1994, scientists from a few centres in Poland worked out a project for recovering migrating fishes, including sturgeon (Sych, 1996). On the basis of this project, sturgeon recovery in the Oder and Vistula River systems has been proposed, based in part on former migration routes. For the Oder River system, they propose restitution between the Oder-Warta-Notec to the Drawa and Gwda Rivers. The Vistula River system would have to be connected with the lower Vistula and Drweca Rivers. Recovery of sturgeon is still distant, because of the deficiency of stocking material (Kolman, 1996). A project for recovery of migrating fishes was submitted to the government of Poland in 1996.

REFERENCES

- Anon. 1883. Die Westpreussischen Flüsse und die in Verbindung mit ihnen stehenden Seen. *Fisch. Ver. Prov. Westpreussen* (Danzig) 48: p. 2.
- Anon. 1886. Störe und Störfischerei an der preussischen Ostseeküste. *Berichte des Fischerei-Vereins der Provinzen Ost- und Westpreussen* 1: 1-4.
- Anon. 1887. Sturgeon fishery near Prussian coast. *Vestnik Rybopromyslennosti* 4: 149-150 (in Russian).
- Anon. 1898a. Ein Stör. *Fischerei Zeitung* (Neudamm) 1: p. 437.
- Anon. 1898b. Störfang in der Weichsel. *Fischerei Zeitung* (Neudamm) 1: p. 514.
- Anon. 1899. Grosse Störe. *Fischerei Zeitung* (Neudamm) 2: p. 326.
- Anon. 1900. Ein Stör. *Fischerei Zeitung* (Neudamm) 3: p. 400.
- Anon. 1919. Ein Stör bei Breslau. *Fischerei Zeitung* (Neudamm) 22: p. 302.
- Anon. 1923. Allerlei vom Stör. *Fischerei Zeitung* (Neudamm) 26: p. 162.
- Anon. 1925. Sturgeon in Dunajec river. *Rybak Pol.* 6: p. 11 (in Polish).
- Anon. 1936. Stör in der Oder. *Fischerei Zeitung* (Neudamm) 39: p. 514.
- Anon. 1956. The last of the Mohicans. *Gospodarka Rybna* 10: p. 20 (in Polish).
- Anon. 1965. Sturgeon was caught. *Gospodarka Rybna* 12: p. 21 (in Polish).
- Bartel, R. 1968. Appearance of sturgeons near shore of Vistula Peninsula. *Gospodarka Rybna* 4: 15-16 (in Polish).
- Benecke, B. 1881. *Fische, Fischerei und Fischzucht*. Hartungsche Verlagsdruckerei. Königsberg: 514 pp.
- Berg, L. S. 1911. *Fauna of Russia and the neighbouring countries. I. Marsipobranchii, Selachii and Chondrostei*. Tipografija

- Imperialnoj Akademii Nauk. St. Petersburg: 337 pp. (in Russian).
- Bloch, M. E. 1784. *Oekonomische Naturgeschichte der Fische Deutschlands*. Teil 3. Berlin: 234 pp.
- Blazejewski, J. 1934. Fisheries in the Pomeranian Vistula. *Przegląd Rybacki* 7: 454-461 (in Polish).
- Borne, M. 1882. *Die Fischerei-Verhältnisse des Deutschen Reiches, Oesterreich-Ungarns, der Schweiz und Luxemburgs*. W. Moeser. Berlin: 306 pp.
- Chrzanowski, F. 1947. A rare guest from acipenserid family. *Przegląd Rybacki* 14: 418-421 (in Polish).
- Demel, K. 1924. *Fishes of the Polish Baltic Sea*. Bibl. Przyr. i Tech. Lwow-Warsaw: 48 pp. (in Polish).
- Demel, K. 1925. A record of fishes of our Baltic Sea. *Archiwum Rybactwa Polskiego* 1: 50-54 (in Polish).
- Demel, K. 1927. Resources of our sea. *Archivum Hydrobiologii i Rybactwa* 2: 69-118 (in Polish).
- Demel, K. 1933. A record of invertebrates and fishes of our Baltic Sea. *Fragmenta Faunistica* 2: 121-136 (in Polish).
- Dyduch, A. 1979. The history of the sturgeon *Acipenser sturio* in Polish waters. *Chronmy Przyrody Ojczyzna* 35: 12-27 (in Polish).
- Fiszer, Z. 1896. Sturgeon in the Vistula River. *Okólnik Rybacki* 22: p. 17 (in Polish).
- Gasowska, M. 1962. *Cyclostomi et Pisces*. Powszechne Wydawnictwo Naukowe. Warsaw, Cracow: 240 pp. (in Polish).
- Gloger, C. L. 1833. *Schlesiens Wirbelthier-Fauna. Ein systematischer Ueberblick der in dieser Provinz vorkommenden Säugethiere, Vögel, Amphibien und Fische*. Druck und Verlag von Grass, Barth und Co. Breslau: 78 pp.
- Grabda, E. 1968. Sturgeon, a vanishing fish. *Ochrona Przyrody* 33: 177-191 (in Polish).
- Grabda, E. 1971. Sturgeon, a living monument of nature. *Przyroda Polska* 15: 10-11 (in Polish).
- Grabda, E. and D. Waluga. 1968. Contribution à la pathologie de l'esturgeon occidental *Acipenser sturio* L. *Acta Hydrobiologica* (Cracow) 10: 131-135.
- Grotian, H. 1896. Die Fischereiverhältnisse der Warthe. *Fischerei Zeitung* (Beil. Deutsch) 19-22: 194-222.
- Heckel, J. and R. Kner. 1858. *Die Süßwasserfische der Österreichischen Monarchie mit Rücksicht auf die angrenzenden Länder*. W. Engelmann. Leipzig: 388 pp.
- Heinrich, A. 1856. *Mährens und k.k. Schlesiens Fische, Reptilien und Vögel. Ein Beitrag zur Fauna beider Kronländer*. Brünn: 201 pp.
- Holland, T. 1871. *Die Wierbelthiere Pommerns*. W. Saunier. Stolp: 119 pp.
- Jachno, J. 1867. About the fauna of the Sandomierz forest. *Sprawozdania Komitetu Fizjograficznego* (Cracow) 1: 129-133 (in Polish).
- Jakubski, A. W. 1924. Fishery areas of the Polish Baltic Sea. *Roczniki Nauk Rolniczych* 11: 169-208 (in Polish).
- Jaskowski, J. 1962. Materials on the knowledge about the ichthyofauna of Warta river and tributaries. *Fragmenta Faunistica* 9: 449-499 (in Polish).
- Jajdzewski, K. 1954. The customs of fishermen in Gdansk in the 12th and 13th centuries in the light of archaeological findings from 1948-51. *Rocznik Gdanski* 13: 7-28 (in Polish).
- Kaj, J. 1948. An outline of fishery physiography of Western Pomerania. *Przegląd Rybacki* 15: 395-407 (in Polish).
- Kajzer, T. 1966. A rare and valuable specimen of fish. *Wiadomości Wędkarskie* 4: 5 (in Polish).
- Kardaszewski, A. 1947. Fisheries and waters of Western Pomerania. *Przegląd Rybacki* 14: 407-415 (in Polish).
- Klinsmann, N. 1848. Naturwissenschaftliche Bemerkungen auf einer Reise durch Preussen. *Neue Preussische Prov.-Bl. (Königsberg)* 5: 378-383.
- Kluk, K. 1780. *Natural history of domestic and wild animals, especially of local origin. Third volume about reptile and fish*. Druck J. K. Mosci i Rzeczypospolitej. Warsaw: 504 pp. (in Polish).
- Kolman, R. 1996. Past and future of sturgeons in Poland. *Zoologica Poloniae* 41: 171-178 (in Polish).
- Kornaszewski, A. 1907. Vom Stör in der Warthe. *Fischerei Zeitung* (Neudamm) 10: p. 734.
- Kowalski, J. M., W. Mierzejewski, E. Niezabitowski and S. Udziela. 1910. *A key for recognition of vertebrate animals of Polish lands*. W. Kornecki. Cracow: 344 pp. (in Polish).
- Kozikowska, Z. 1957. Parasitic crustaceans (Crustacea parasitica) of. Part I. Parasites of lower Odra River's waters. *Zoologica Poloniae* 8: 217-270 (in Polish).
- Kraczkiewicz, W. 1967. Occurrence of sturgeon *Acipenser sturio* L. in area of Odra River mouth. *Przegląd Zoologiczny* 11: 149-151 (in Polish).
- Kujawa, S. 1962. Sturgeon (*Acipenser sturio* L.) caught in the Firth of Vistula. *Annales Biologiques* (Copenhagen) 17: p. 118.
- Kulmatycki, W. 1926. An attempt to describe of fishery physiography of Poland. *Roczniki Nauk Rolniczych* 15: 102-149 (in Polish).
- Kulmatycki, W. 1929. Pollution of fishery waters by wastes from industry in western provinces. *Gazeta Rolnicza* 15/16: 532-535 (in Polish).
- Kulmatycki, W. 1932a. About protection of the sturgeon in Polish rivers. *Ochrona Przyrody* 12: 8-28 (in Polish).
- Kulmatycki, W. 1932b. Delayed sturgeon. *Przegląd Rybacki* 11: 44 (in Polish).
- Kulmatycki, W. 1936. Hydrography and ichthyofauna of rivers of Lodz province. *Czasopismo Przyrodnicze Ilustrowane* 10: 123-150 (in Polish).
- Kutrzeba, S. 1918. The Vistula river in the economic history of Poland. *Polskie Wiadomości Gospodarcze* 33-34: 3-4 (in Polish).
- Ladowski, S. P. 1804. *Natural history of Poland country*. T. I. Druk, J. Grebel. Cracow: 340 pp. (in Polish).
- Lega, W. 1949. *Economic picture of Gdansk Pomerania in XII and XIII ages*. Instytut Zachodni Poznan: 260 pp. (in Polish).
- Maleczynski, K. 1963. *History of Silesia. Part III: from the end of the 16th century to 1763*. Ossolineum. Wrocław, Warsaw, Cracow: 626 pp. (in Polish).
- Michalski, K. 1967. Is the restitution of sturgeon in Polish waters possible? *Przegląd Zoologiczny* 3: 262-268 (in Polish).
- Mikolajski, J. and A. Wodziczko. 1929. *A physiographical outline of Pomerania*. Instytut Bałtycki. Torun: 87 pp. (in Polish).

- Mikulski, Z. 1963. *An outline of the hydrography of Poland*. Powszechnie Wydawnictwo Naukowe. Warsaw: 286 pp. (in Polish).
- Möbius, K. and F. Heincke. 1883. *Die Fische der Ostsee*. Paul Parey. Berlin: 206 pp.
- Mohr, E. 1952. *Der Stör*. Die Neue Brehm Bucherei. Leipzig: 65 pp.
- Nabialek, J. 1974. Sturgeons in Vistula river. *Gospodarka Rybna* 1: 10 (in Polish).
- Nabialek, J. 1976. Again about sturgeons. *Gospodarka Rybna* 3: 6 (in Polish).
- Nowicki, M. 1879. *Our fishes, their local names, distribution in waters, season and site of spawning*. W. Kornecki. Cracow: 4 pp. (in Polish).
- Nowicki, M. 1880. *Fishes of Galicia and their fisheries*. W. Kornecki. Cracow: 106 pp. (in Polish).
- Nowicki, M. 1889. *About fishes of the Vistula, Sty, Dnestr and Prut Rivers in Galicia*. F. Kluczycki. Cracow: 54 pp. (in Polish).
- Olszewski, P. 1948. The beginning of fisheries in Mazuria. *Przegląd Rybacki* 11: 457-459 (in Polish).
- Pax, F. 1916. Wandlungen der schlesischen Tierwelt in geschichtlicher Zeit. *Beiträge der Naturdenkmale Pflügen* (Berlin) 5: 414-472.
- Pax, F. 1921. *Die Tierwelt Schlesiens*. G. Fischer. Jena: 342 pp.
- Pax, F. 1925a. Die Tierwelt Schlesiens. *Ostdeutscher Naturwart* (Liegnitz) 2: 1-4.
- Pax, F. 1925b. *Wirbeltierfauna von Schlesien. Faunistische und tiergeographische Untersuchungen im Odergebiet. V. Pisces*. G. Fircher. Berlin: 516-537.
- Poczopko, P. 1955. An outline of the fishery in the Vistula River near Torun in 1952-1954. *Roczniki Nauk Rolniczych B-70*: 107-120 (in Polish).
- Przybyl, A. 1976. The occurrence of the sturgeon *Acipenser sturio* in the catchment area of the Warta River. *Chronmy Przyrode Ojczyzna* 32: 5-12 (in Polish).
- Rathke, H. 1824. Über den Darmkanal und die Zeugungsorgane der Fische. *Neue Schriften des Naturforschung Gesamten* (Danzig) 1: 210 pp.
- Rolik, H. 1959. Giant sturgeon from the Bug-Narew River. *Gospodarka Rybna* 11: 19-20 (in Polish).
- Ropelewski, A. 1963. *A thousand years of our fisheries*. Wydawnictwo Morskie. Gdynia: 158 pp. (in Polish).
- Rudnicki, A. 1963. Sturgeon. *Wiadomości Wędkarskie* 12: 12 (in Polish).
- Rudnicki, A. 1966. Sturgeon - conservation, poaching. *Gospodarka Rybna* 18: 21-22 (in Polish).
- Rybczynski, M. 1934. *Pomeranian Vistula*. Instytut Bałtycki. Torun: 40 pp. (in Polish).
- Rybczynski, M. 1935. *Waterways in Pomerania*. Instytut Bałtycki. Torun: 120 pp. (in Polish).
- Rzaczyński, G. 1721. *Historia naturalis curiosa Regni Poloniae, Magni Ducatus Lituaniae, annexarumque provinciarum, in tractatus XX divisa: ex scriptoribus probatis, servata primigenia eorum phrasi in locis plurimis, ex M.S.S. variis, testibus, oculatis, relationibus fide dignis, experimentalis, desumpta*. Typis Coll. S. J. Sandomiriae: 456 pp.
- Rzaczyński, G. 1736. *Auctuarium historiae naturalis-curiosae Regni Poloniae, Magni Ducatus Lituaniae Annexarumque Provinciarum in puncta duodecim divisum*. Druk. Miltzerowska. Gedani: 504 pp.
- Sakowicz, S. 1930. Conservation of sturgeon. *Przegląd Rybacki* 3: p. 204 (in Polish).
- Sakowicz, S. 1931. More about sturgeon. *Przegląd Rybacki* 4: 311-312 (in Polish).
- Samsonowicz, H. 1967. *History of Poland to 1795*. Państwowe Zakłady Wydawnictw Szkolnych. Warsaw: 250 pp. (in Polish).
- Sasorski, M. 1922. About catches of salmon and sturgeon in the Vistula River near Cracow. *Rybak Polski* 3: 346-347 (in Polish).
- Schulz, C. 1911. *Studien über die Posener Wirbeltierfauna. Festschr. 50. Versam. Deutsch. Phil. Schulm. Posen*: 20 pp.
- Schulz, C. 1912. *Studien über die Posener Wirbeltierfauna. Festschr. 51. Versam. Deutsch. Phil. Schulm. Posen*: 29 pp.
- Seligo, A. 1902. *Die Fischgewässer der Provinz Westpreussen*. Commissionsverlag von Saunier's Buch und Kunsthandlung. Danzig: 193 pp.
- Seligo, A. 1906. Störzucht in der Weichsel. *Mitteilungen des Westpreussischen Fischerei-Verband* (Danzig) 18: 14-15.
- Seligo, A. 1919. Der Lachs- und Störfang in der Weichsel oberhalb des Danziger Hauptes und in der Brahe 1918. *Mitteilungen des Westpreussischen Fischerei-Verband* (Danzig) 31: 14-15.
- Seligo, A. 1920. Das Leben im Weichselstrom. *Mitteilungen des Westpreussischen Fischerei-Verband* (Danzig) 32: 1-4.
- Siebold, C. T. E. 1863. *Die Süßwasserfische von Mitteleuropa*. W. Engelmann. Leipzig: 431 pp.
- Sobieszczański, F. M. 1894. Ichthyofauna in the Vistula River near Warsaw. *Okólnik Rybacki* 11: 21-22 (in Polish).
- Staff, F. 1950. *Freshwater fishes of Poland and the neighbouring countries*. Trzaska, Evert & Michalski. Warsaw: 273 pp. (in Polish).
- Starmach, K. 1951. Sturgeon in Polish waters and its conservation. *Chronmy Przyrode Ojczyzna* 7: 38-43 (in Polish).
- Sych, R. 1996. About the project of migratory fish restoration in Poland. *Zoologica Poloniae* 41: 47-59 (in Polish).
- Szmyt, J. 1904. Fisheries in Greater Poland. *Okólnik Rybacki* 72: 266-272 (in Polish).
- Taczanowski, L. 1877. Liste des vertébrés de Pologne. *Bulletin. Societe Zoologique de France* 2: 121-174.
- Tobiasz, M. 1962. *The guild of fisherman in Cracow*. Wydawnictwo Wyższej Szkoły Rolniczej. Olsztyn: 96 pp. (in Polish).
- Turoboyski, K. 1968. European sturgeon *Acipenser sturio* L. in the Gulf of Gdansk. *Przegląd Zoologiczny* 12: 291-292. (in Polish).
- Urbanowicz, K. 1965. Catches of European sturgeon *Acipenser sturio* L. in the early medieval Gdansk in the light of archaeological findings. *Przegląd Zoologiczny* 9: 372-375 (in Polish).
- Walecki, A. 1863. Materials about the ichthyofauna of Poland. *Biblioteka Warszawska* (Warsaw) 4: 325-364 (in Polish).
- Walecki, A. 1864. *A systematic survey of local fishes*. Drukarnia Gazety Polskiej. Warsaw: 115 pp. (in Polish).
- Walecki, A. 1889. A contribution to our ichthyofauna. *Pamiętniki Fizjograficzne* 9: 275-295 (in Polish).

- Wilkosz, F. 1896. A tale about a giant sturgeon! *Okólnik Rybacki* 23: p. 24 (in Polish).
- Wilkosz, F. 1904. Fisheries in the Kingdom of Poland, in Podole, Wolyn and Ukraine. *Okólnik Rybacki* 72: 280-286 (in Polish).
- W. J. S. 1929. An unusual specimen of sturgeon. *Przegląd Rybacki* 2: 435 (in Polish).
- Wunder, W. 1933. Die Laichzeit der Fische und andere Fischereifragen unter besonderen Berücksichtigung des Sportangels. *Zeitschrift Landwirtschaftliches Kamm.* (Breslau) 7: 51-53.
- Zawadzki, A. 1840. *Fauna der galizisch-bukowinischen Wirbelthiere. Eine systematische Uebersicht der in diesen Provinzen mit vorkommenden Säugethiere, Vögel, Amphibien und Fische, mit Rücksicht auf ihre Lebensweise und Verbreitung. D. Fische. Pisces.* Schweizerharts Verhandlung. Stuttgart: 162-182.
- Zelechowska, J. 1964. Sturgeon in the Vistula River near Torun. *Gospodarka Rybna* 16: 6-7 (in Polish).